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Tanta University
Faculty of engineering
Electrical Power and Machines engineering department
Energy Conversion Course

Sheet (3) ...... Electrical Transformers

1) The no-load current of a transformer is 10 A at a power factor of 0.25 lagging, when connected to 400 V, 50 Hz supply. Calculate:

P.122

a) Magnetizing component of no-load current. 5
b) Iron loss and c) Maximum value of flux in the core assume that primary winding turns are 500.

2) A 15 kVA, 2200/110 V transformer has R_1=1.75 Ω, R_2=0.0045 Ω. The leakage reactances are X_1=2.6 Ω and X_2=0.0075 Ω. Calculate:

P.133

a) Equivalent resistance referred to primary
b) Equivalent resistance referred to secondary
c) Equivalent reactance referred to primary
d) Equivalent reactance referred to secondary
e) Equivalent impedance referred to primary
f) Equivalent impedance referred to secondary
g) Total cupper loss

3) 250/125 V, 5 kVA single phase transformer has primary resistance of 0.2 Ω and reactance of 0.75 Ω. The secondary resistance is 0.05 Ω and reactance of 0.2 Ω.

P.144

a) Determine its regulation while supplying full load on 0.8 leading p.f.
b) The secondary terminal voltage on full load and 0.8 leading p.f.

4) A 4 kVA, 200/400 V, 50 Hz, single phase transformer has equivalent resistance referred to primary as 0.15 Ω. Calculate:

P.148

a) The total copper loss on full load
b) The efficiency while supplying full load at 0.9 p.f lagging
c) The efficiency while supplying half load at 0.8 p.f lagging

Assume total iron losses = 60 W.

5) A 5 kVA, 500/250 V, 50 Hz, single phase transformer gave the following readings,

P.159

O.C. Test: 500 V, 1 A, 50 W (L.V. side open)
S.C. Test: 25 V, 10 A, 60 W (L.V. side shorted)

Determine:

a) η % on full load, 0.8 lagging p.f.
b) The voltage regulation on full load, 0.8 leading p.f.
c) η % on 60% of full load, 0.8 leading p.f.
d) Draw the equivalent circuit referred to primary and insert all the values in it.

P.161

6) The O.C. and S.C. tests on a 10 kVA, 125/250 V, 50 Hz, single phase transformer gave the following results:

O.C. Test: 125 V, 0.6 A, 50 W (on L.V. side)

5 S.C. Test: 15 V, 30 A, 100 W (on H.V. side)

Calculate:

a) Copper loss on full load

b) Full load η % at 0.8 leading p.f.

c) Half load η % at 0.8 leading p.f.

d) Regulation at full load, 0.9 leading p.f.

P.171

7) A 2500/250 V, 50 Hz, 50 kVA, single phase transformer has a resistance of 0.8 Ω and 0.012 Ω and a reactance of 4 Ω and 0.04 Ω for H.V. and L.V. windings respectively. Transformer gives 96% maximum efficiency at 75% full load at unity p.f. The magnetizing component of no load current is 1.2 A on 2500 V side. Find out ammeter, voltmeter and wattmeter readings on O.C and S.C. test if supply is given to the 2500 V side in both cases.

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problem ①

Sheet (3) Solution

$I_o = 10\,A$ at $P.f._o = 0.25$ lag, $V_1 = 400\,V$, $f = 50\,Hz$

Calculate:

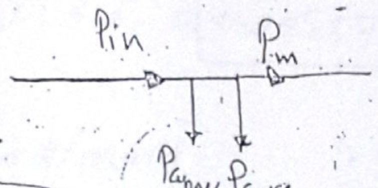
① I_m ② Iron loss ③ Max. value of flux in the Core if $N_1 = 500$

① $I_m = I_o \sin \phi_o$ $\quad \boxed{P.f._o = \cos \phi_o}$

$\phi_o = \cos^{-1}(0.25) = 75.522$

$\therefore I_m = 10 * \sin(75.522) = \boxed{9.6824\,A}$ # ①

② at no-load



$P_{Iron} = V_1 * I_c$

$I_c = I_o \cos \phi_o = \boxed{2.5\,A}$

$\boxed{P_{iron} = 1000\ watt}$

③ $\phi_m = ?$

$\therefore E_1 = 4.44\, f\, \phi_m\, N_1$

$400 = 4.44 * 50 * \phi_m * 500$

$\therefore \boxed{\phi_m = 3.6036\ mwb}$

for problem ②

$P_{copper\,sec} = I_1^2 * R_t\Big|_{sec} = \left(\frac{15*10^3}{110}\right)^2 * 0.008875 = \boxed{165.031\ watt}$

لابد أن يكونوا متساويين

or

$P_{copper\,total} = I_1^2 * R_1 + I_2^2 * R_2$

$= \left(\frac{15000}{2200}\right)^2 * 1.75 + \left(\frac{15000}{110}\right)^2 * 0.0045 = \boxed{165.031\,w}$

15KVA, 2200/110V, has $R_1 = 1.75\Omega$, $R_2 = 0.0045\Omega$, $X_1 = 2.6$
$X_2 = 0.0075\Omega$

a) R_t Refered to Primary

أول

$R_1 = 1.75\Omega$, $R'_2 = 0.0045 * \left(\frac{2200}{110}\right)^2 = 1.8\Omega$

الى تأصلها

تربيع

$\therefore R_t|_{pri} = R_1 + R'_2 = \boxed{3.55\Omega}$

الى انطلع منه

b) R_t Reffred to Secondary

$R_2 = 0.0045\Omega$, $R'_1 = 1.75 * \left(\frac{110}{2200}\right)^2 = \boxed{4.375 * 10^{-3}\Omega}$

$\therefore R_t|_{sec} = 8.875 * 10^{-3} = \boxed{0.008875\Omega}$

c) X_t Refered to primary

$X_1 = 2.6\Omega$, $X'_2 = 0.0075 * \left(\frac{2200}{110}\right)^2 = 3\Omega$

$\therefore X_t|_{prim} = \boxed{5.6\Omega}$

d) X_t Refered to secondary

$X_2 = 0.0075\Omega$, $X'_1 = 2.6 * \left(\frac{110}{2200}\right)^2 = 6.5 * 10^{-3}\Omega$

$\therefore X_t|_{sec} = 0.014\Omega$

e) Z_t Ref. to primary

$Z_t|_{prim} = \sqrt{(R_t|_{prim})^2 + (X_t|_{prim})^2} = \boxed{6.6304\Omega}$

f) Z_t Ref. to secondary

$Z_t|_{sec} = \sqrt{(R_t|_{sec})^2 + (X_t|_{sec})^2} = \boxed{0.01657\Omega}$

e) total Copper loss

$P_{copper}|_{prim} = I_1^2 * R_t|_{prim} = \left(\frac{15 * 10^3}{2200}\right)^2 * 3.55 = \boxed{165.031 \text{ watt}}$

check الى مكتوب بالأعلى ① الباقي

Problem (3)

250/125 V XFMR, $S = 5\,KVA$, $1-\phi$, $R_1 = 0.2\,\Omega$, $X_1 = 0.75\,\Omega$, $R_2 = 0.05\,\Omega$, $X_2 = 0.2\,\Omega$

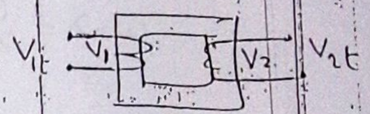
① Regulation for full load on 0.8 P.f lead

② V_2 on full load and 0.8 P.f lead

(الحل)

$\because R_1 = 0.2\,\Omega$, $X_1 = 0.75\,\Omega$, $R_2 = 0.05\,\Omega$, $X_2 = 0.2\,\Omega$, $\cos\phi = 0.8$ leading

① → Refered to secondary.



$$R_1' = \underset{0.2}{R_1} * \left(\frac{125}{250}\right)^2 = 0.05\,\Omega$$

$$\therefore R_{t\,sec} = 0.05 + 0.05 = \boxed{0.1\,\Omega}$$

$$X_1' = \underset{0.75}{X_1} * \left(\frac{125}{250}\right)^2 = 0.1875\,\Omega$$

$$\therefore X_t\big|_{sec} = \boxed{0.3875\,\Omega}$$

$$I_{sec} = \frac{S}{V_{sec}} = \frac{5*10^3}{125} = 40\,A = I_2$$

$$\%R = \frac{I_2 R_{t\,sec} \cos\phi \pm I_2 X_{t\,sec} \sin\phi}{V_2} * 100$$

+ → Lag P.f

− → Lead P.f

$$\phi = \cos^{-1}(0.8) = 36.869^\circ$$

$$\therefore \sin\phi = 0.6$$

Lead

$$\therefore \%R = \frac{40 * 0.1 * 0.8 - 40 * 0.3875 * 0.6}{125} * 100 = -4.88\%$$

② the same Load

$$\%R = \frac{V_2 - V_{2t}}{V_2} \Rightarrow -4.88 = \frac{125 - V_{2t}}{125}$$

V2t → terminal Voltage

$$\therefore \boxed{V_{2t} = 131.1\,V}$$

leading لأنها $V_{2l} < V_{2t}$ ان الاختلاف م

(2 لـ...)

4KVA ; 200/400 V ; 50Hz XFMR 1-φ

$R_{t\,prim} = 0.15\,\Omega$, iron loss = 60W

① P_{copper} total on full load

② η full-load at 0.9 P.f lag

③ η half-load at 0.8 P.f lead

اكمل

$V_1 = 200\,V$, $V_2 = 400\,V$, $R_{t\,pr} = 0.15$, P_i or $P_{core} = 60\,W$

①

$\therefore R_{t\,sec} = 0.15 * \left(\frac{400}{200}\right)^2 = \boxed{0.6\,\Omega}$ Refered to secondary

$I_{2\,f.L} = \frac{S}{V_2} = \frac{4000}{400} = 10\,A$

$\therefore P_{copper} = I_{2\,f.L}^2 * R_{t\,sec} = 10^2 * 0.6 = \boxed{60\,W}$ # or

$P_{copper} = I_{f.L}^2 R_{t\,prim}$

$\left(\frac{2000}{200}\right)^2 * 0.15 = 60$

② $\therefore \eta = \frac{S\cos\phi}{S\cos\phi + P_i + P_{copper(f.L)}}$

$\frac{P_{out}}{P_{in}}$ $\frac{P_{out}}{P_{out} + P_{i} + P_{c}}$

$\therefore \eta$ at $\cos\phi = 0.9$ lag (full-load)

$\therefore \eta = \frac{4*10^3 * 0.9}{4*10^3 * 0.9 + 60 + 60} * 100 = 96.77\%$

η = Pout / Pin

$= \frac{P_{out}}{P_{out} + P_{iron} + P_{cu}}$

③ when the load reduced to half

$n = \frac{\text{actual load}}{\text{full load}}$ = fraction by which load is less than full load

عندما يزداد التحميل يتغير التيار بنفس النسبة

$\therefore I_{2\,new} = n\, I_{2\,f.L}$, also $P_{copper\,new} = n^2 P_{copper(f.L)}$, $P_{out\,new} = n\, P_{out\,(f.L)}$

ايضا ال $P_{out} \leftarrow V_2 I_2 \cos\phi$ تقل بنفس النسبة لكن P_{copper}

$\therefore \eta = \frac{n * S * \cos\phi}{n * S * \cos\phi + P_i + n^2 P_{copper(f.L)}}$

$= \frac{0.5 * 4 * 10^3 * 0.8}{0.5 * 4 * 10^3 * 0.8 + 60 + (0.5^2) * 60}$

$\boxed{\therefore \eta = 95.52\%}$

لأن ال loss زادت

$R_1 \times R_2$

R_{eq} , $R_{eq\,sec}$

④